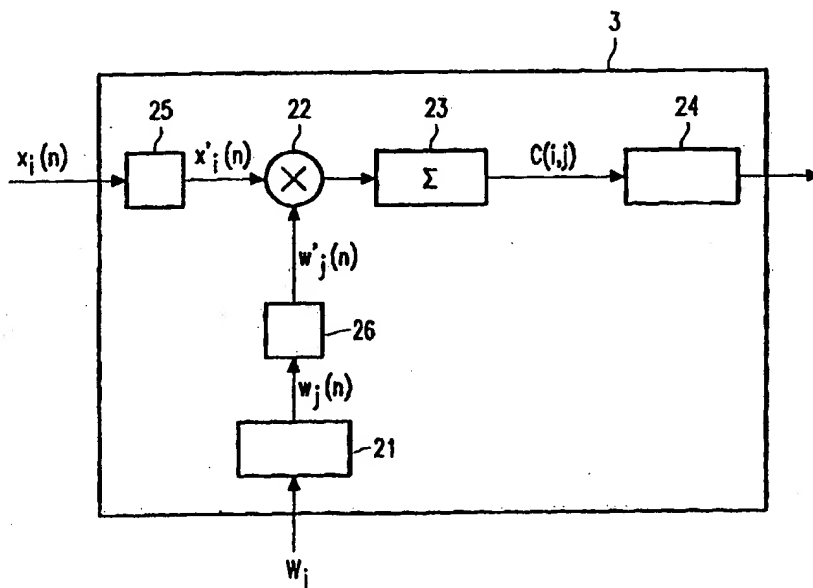




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(21) International Application Number: PCT/IB97/00692 (22) International Filing Date: 12 June 1997 (12.06.97) (30) Priority Data: 96202016.0      16 July 1996 (16.07.96)      EP (34) Countries for which the regional or international application was filed: AT et al. (71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE). (72) Inventor: LINNARTZ, Johan, Paul, Marie, Gerard; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: SCHMITZ, Herman, J., R.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).		(81) Designated States: JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	

(54) Title: DETECTING A WATERMARK EMBEDDED IN AN INFORMATION SIGNAL



## (57) Abstract

A watermark embedded in an information signal is detected by correlating said information signal with a plurality of watermarks  $W_j(n)$ . The respective amounts of correlation  $C(i,j)$  are then evaluated to determine the watermark embedded in the signal  $x_i(n)$ . The invention provides a significant improvement of the detection by predictive filtering (25) the information signal and/or predictive filtering (26) the applied watermark prior to the process of correlating the signals.

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Detecting a watermark embedded in an information signal.

The invention relates to a method of detecting a watermark embedded in an information signal, comprising a correlation step for correlating said signal and an applied watermark, and an evaluation step for evaluating the result of said correlation. The invention also relates to a method for carrying out said method.

5

Watermarks are perceptually invisible messages embedded in multimedia content such as audio, still images, animations or video. They comprise information, for example, about the source or copy right status of documents or audiovisual programs. Watermarks can be used to provide legal proof of the owner of the copyright. They allow tracing of piracy and support the protection of intellectual property.

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A known method of detecting a watermark embedded in an information signal comprises a correlation step for correlating said signal and an applied watermark. The result of said correlation is then evaluated. For example, if the amount of correlation is larger than a predetermined value, the applied watermark may be considered to be the watermark embedded in the signal. Alternatively, a number of successive correlation steps can be carried out for different applied watermarks. The applied watermark yielding the largest correlation is then considered to be the watermark embedded in the signal.

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#### OBJECT AND SUMMARY OF THE INVENTION

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It is an object of the invention, inter alia, to provide a method with which an embedded watermark can yet more reliably be detected.

To that end, the method is characterized by the steps of predictive filtering the information signal or the applied watermark or both, and applying the correlation step to said filtered signal and said filtered watermark.

25

The invention is based on the recognition that the problem of detecting watermarks closely resembles the detection of weak radio or radar signals in the presence of strong interference or noise. By predictive filtering, i.e. subtracting a prediction of the information signal from said signal, a residual signal is obtained having a significant lower

variance. This means that the interference which the watermark suffers from the residual information is considerably less than it suffers from the original signal.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

Fig.1 shows schematically an arrangement for watermarking a video signal.

Fig.2 shows schematically a prior art arrangement for detecting a watermark embedded in the signal which is generated by the arrangement shown in Fig.1.

Figs. 3 and 4 show schematically arrangements for detecting the watermark in accordance with the invention.

The invention will herein be described by way of an example of detecting a watermark which is embedded in a digital video signal. The watermarks can be added in almost every domain such as, for example, the time domain, the spatial domain, the transform domain after DCT or Fourier transform, etc. In the present example, it is embedded in the spatial domain, i.e. it is added to the luminance pixel values of a digital video signal.

Fig.1 shows schematically an arrangement 1 for watermarking the video signal. The arrangement receives a video signal in the form of luminance samples or pixels  $p(n)$  and a watermark  $W_i$ . The watermark can be a code which uniquely identifies the owner of the copyright. It can also be a text string or simply a binary coded number. Accordingly, there is a finite set of different watermarks  $W_i$ . The arrangement comprises a watermark data signal generator 11 which generates a predetermined watermark data signal  $w_i(n)$  for each watermark  $W_i$ . The luminance value  $p(n)$  and watermark data value  $w_i(n)$  are added by an adder 12 pixel-by-pixel. Accordingly, the output signal  $x_i(n)$  of the watermarking circuit 1 is:

$$x_i(n) = p(n) + w_i(n)$$

The watermark data signal  $w_i(n)$  is chosen such that it is perceptually invisible when the output signal is displayed on a receiver. For example, a small value is added to the luminance of selected pixels  $p(n)$  of the video image, the watermark  $W_i$  determining the selected pixels. An example hereof will now be given in terms of an image of 8 pixels horizontally and 4 pixels vertically. It is to be noted that the method can also be applied to a predetermined part of the image. The method can also be applied to a plurality of image blocks, each block being associated with a portion of the watermark.

In the present example, the value 1 is added to the luminance of selected pixels whereas other pixels remain unaffected. The following equation denotes a watermark data signal  $w_1(n)$  that is generated by watermark data signal generator 11 in response to a first watermark  $W_1$ :

$$5 \quad w_1(n) = \begin{matrix} 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \end{matrix}$$

The following equation denotes a watermark data signal  $w_2(n)$  that is generated by the watermark data signal generator if a second watermark  $W_2$  is applied:

$$w_2(n) = \begin{matrix} 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \end{matrix}$$

In this manner, the watermark data signal generator 11 generates a different watermark data signal  $w_i(n)$  for each watermark  $W_i$ .

In the present example, the video image is assumed to represent a vertical transition from a luminance value 10 to a luminance value 80. The range of luminance values  $p(n)$  is assumed to be 0-255. In mathematical notation:

$$p(n) = \begin{matrix} 10 & 10 & 10 & 10 & 80 & 80 & 80 & 80 \\ 10 & 10 & 10 & 10 & 80 & 80 & 80 & 80 \\ 10 & 10 & 10 & 10 & 80 & 80 & 80 & 80 \\ 10 & 10 & 10 & 10 & 80 & 80 & 80 & 80 \end{matrix}$$

15 Accordingly, if watermark  $W_1$  is applied to arrangement 1, the watermark data signal  $w_1(n)$  is added to image signal  $p(n)$ , which results in the following output signal  $x_1(n)$ :

$$x_1(n) = \begin{matrix} 10 & 11 & 10 & 11 & 80 & 81 & 80 & 81 \\ 11 & 10 & 11 & 10 & 81 & 80 & 81 & 80 \\ 10 & 11 & 10 & 11 & 80 & 81 & 80 & 81 \\ 11 & 10 & 11 & 10 & 81 & 80 & 81 & 80 \end{matrix}$$

	$W_1$	$W_2$
$x_1(n)$	$C(1,1)=604$	$C(1,2)=544$
$x_2(n)$	$C(2,1)=544$	$C(2,2)=588$

Table IV

5 Fig.4 shows a further embodiment of an arrangement 4 for detecting the embedded watermark. In this arrangement, each pixel of the input signal  $x_i(n)$  is multiplied in a multiplier 42 by a specific weighting factor. The products are summed up in a summation circuit 43 which delivers the correlation value  $C(i,j)$ . A calculating circuit 44 receives the applied watermark  $W_j$  and generates the weighting factors using a model of the statistical  
 10 properties of the information signal. In this embodiment, predictive filtering is not applied to the input signal but embedded in the calculation circuit 44.

In summary, a watermark embedded in an information signal is detected by correlating said information signal with a plurality of watermarks  $W_j(n)$ . The respective amounts of correlation  $C(i,j)$  are then evaluated to determine the watermark embedded in the  
 15 signal  $x_i(n)$ . The invention provides a significant improvement of the detection by predictive filtering (25) the information signal and/or predictive filtering (26) the applied watermark prior to the process of correlating the signals.

Claims

1. A method of detecting a watermark embedded in an information signal, comprising a correlation step for correlating said signal and an applied watermark, and an evaluation step for evaluating the result of said correlation, characterized by the steps of predictive filtering the information signal or the applied watermark or both, and applying the correlation step to said filtered signal and said filtered watermark.  
5
2. The method as claimed in claim 1, wherein the predictive filtering is adapted to predetermined statistical properties of the information signal.
3. The method as claimed in claim 1, wherein both predictive filter steps are the same.
- 10 4. A method of detecting a watermark embedded in an information signal, comprising the step of filtering said signal using filter coefficients determined by an applied watermark, and evaluating the result of said filtering, characterized in that the filter coefficients are further determined by a model of the statistical properties of the information signal.
- 15 5. An arrangement for detecting a watermark ( $W_i$ ) embedded in an information signal, comprising correlation means (22,23) for correlating said signal ( $x_i$ ) and an applied watermark ( $W_i$ ), and evaluation means (24) for evaluating the result of said correlation, characterized by a predictive filter (25) for filtering the information signal or a predictive filter (26) to filter the applied watermark, or both predictive filters, and applying  
20 filtered signal and the filtered watermark to the correlation means.
6. The arrangement as claimed in claim 4, wherein the predictive filters (25,26) are adapted to predetermined statistical properties of the information signal.
7. The arrangement as claimed in claim 5, wherein both predictive filters (25,26) are the same.
- 25 8. An arrangement for detecting a watermark ( $W_i$ ) embedded in an information signal ( $i$ ), comprising a filter (41,42,43) for filtering said signal using filter coefficients, calculation means (44) for calculating said filter coefficients in dependence on an applied watermark ( $W_i$ ), and means (24) for evaluating the result of said filtering,

characterized in that the calculation means (44) are adapted to further determine the filter coefficients in accordance with a model of the statistical properties of the information signal.



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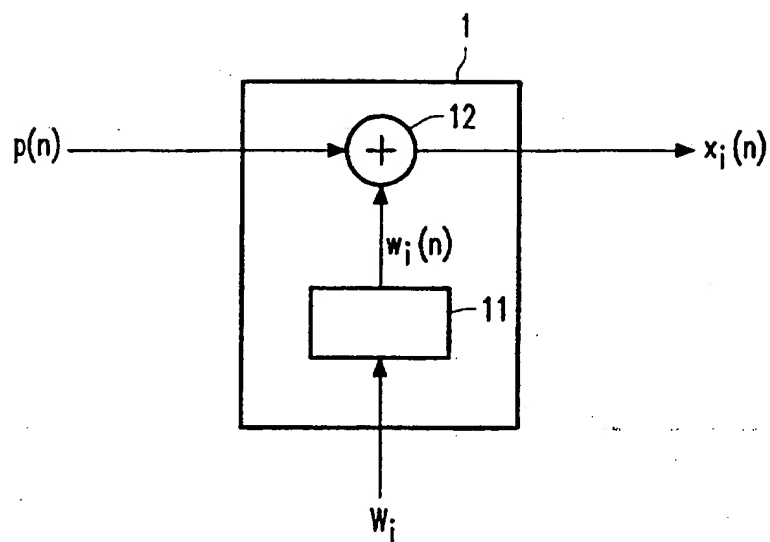


FIG. 1

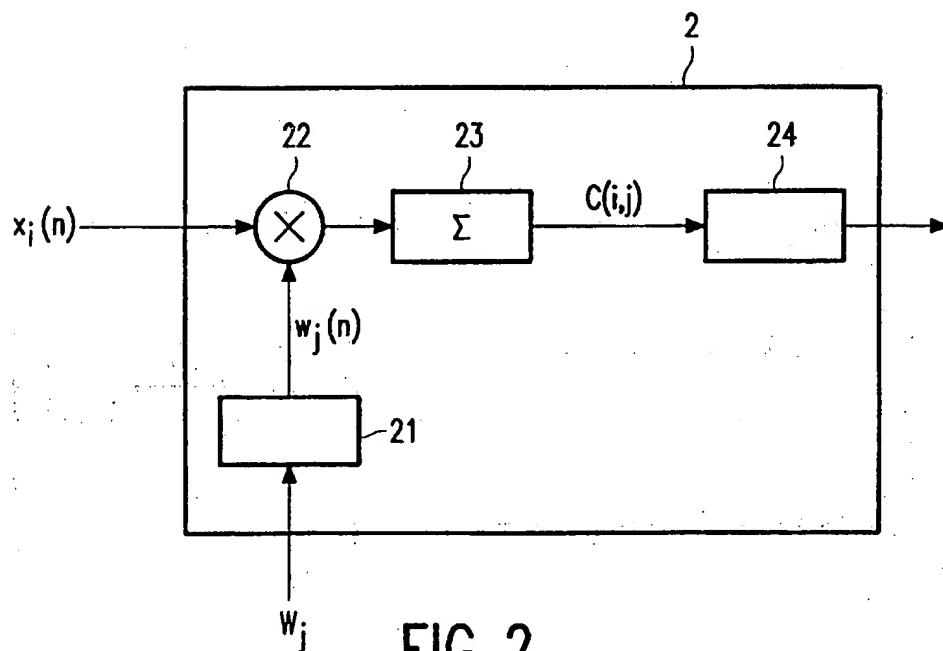
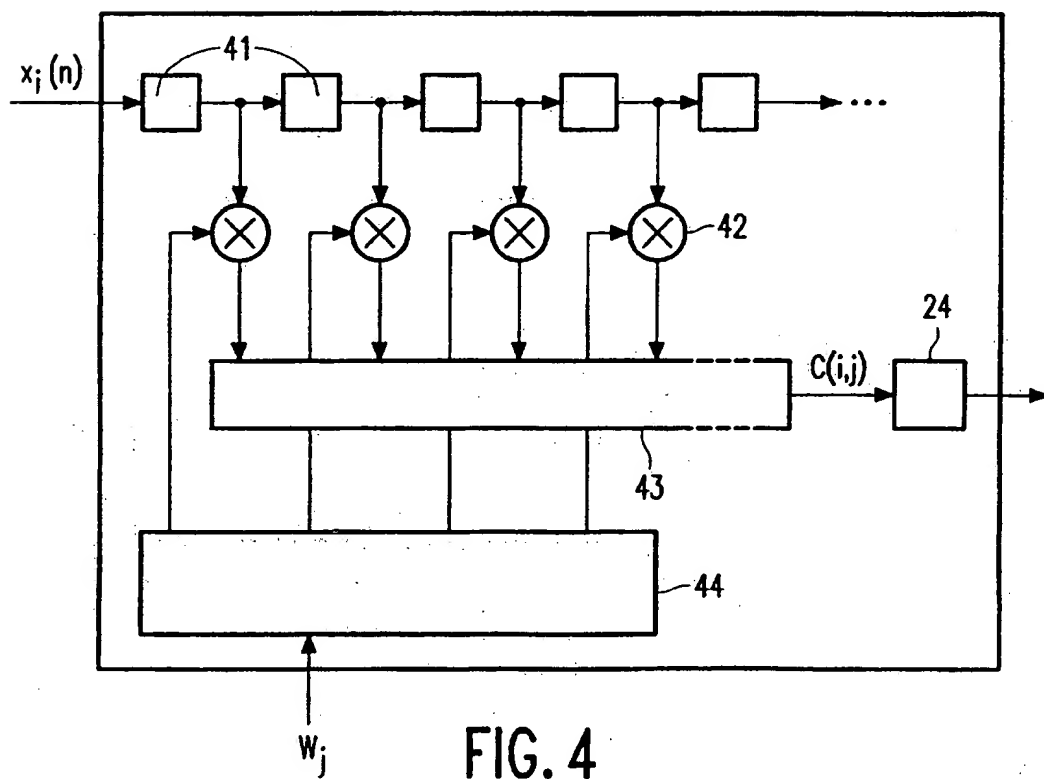
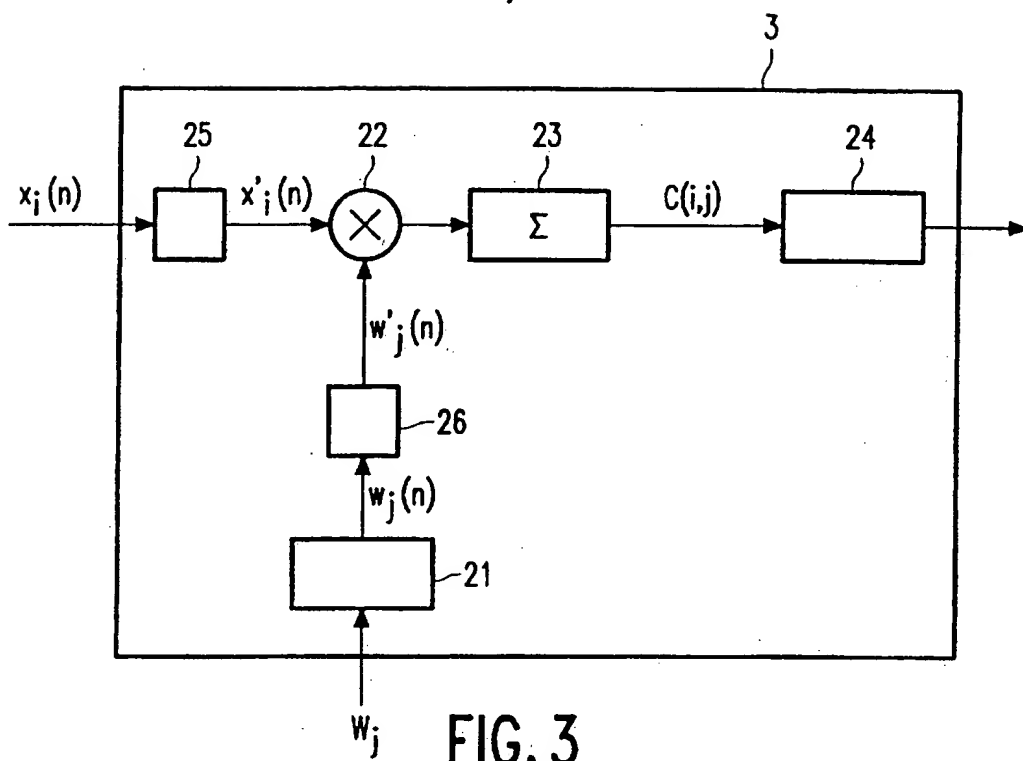


FIG. 2

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00692

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04N 7/08, H04L 9/32

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04N, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, CLAIMS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0766468 A2 (NEC CORPORATION), 2 April 1997 (02.04.97), abstract  --	1-8
A	US 5606609 A (HOUSER ET AL), 25 February 1997 (25.02.97), see whole document  -- -----	1-8

☐ Further documents are listed in the continuation of Box C.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0766468 A2	02/04/97	AU 6584096 A CA 2184949 A	10/04/97 29/03/97
US 5606609 A	25/02/97	NONE	